Large Scale Integral Equation Modeling Using Scalable Parallel Processing

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The evolution of computing hardware and software continues to allow the solution of electromagnetic problems of ever increasing electrical size. This advancement has been a partial stimulus to the development of partial differential techniques such as finite difference or finite element methods, as well as permitting the use of existing integral equation techniques to solve larger problems in shorter amounts of time. Integral equation solutions generally involve geometry description via a computer aided geometry package, matrix fill algorithms which involve the basis functions and all electromagnetic parameters of the scatterer or antenna, matrix equation solution, and finally calculation and display of the observable. For electrically large structures, the matrix equation solution algorithm typically becomes the dominant component of the calculation, both in execution time and needed memory.

Dense matrix solution algorithms are written to optimize both computational speed and storage. Traditional factorization algorithms are used to decompose the general complex-valued, impedance matrix resulting from the integral equation solution into factors that are used to solve for field solutions due to different excitations, The factorization algorithms can use the in-core memory attached to the machine-therefore problem size is limited by this parameter-or out-of-core algorithms which use the associated disk to hold the impedance matrix and its factors. The out-of-core methods therefore allow the solution of much larger problems if the disk space is available. Current developments in non-factorization solution methods use preconditioned iterative algorithms, or low-rank approximations to the linear system, to extend the problem size or reduce the solution time.

In this talk, we will discuss the development of in-core and out-of-core dense matrix solvers, and their integration into existing integral equation codes on distributed memory, scalable parallel processors. Problem sizes exceeding 60,000 unknowns modeling the fields or currents are capable of being solved in less than 100 minutes time for the factorization using an in-core algorithm on a 102,4 processor Cray T3D. Out-of-core algorithms have been developed that run at nearly the same execution rate as the in-core algorithms, extending the problem size limit past this number. The current development in precondit ioned iterative algorithms and low-rank approximations will also be discussed as applied to distributed memory, scalable parallel processing.